

(19)



(11)

EP 3 350 559 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

06.01.2021 Bulletin 2021/01

(51) Int Cl.:

G01M 3/16 ^(2006.01)

G01N 21/956 ^(2006.01)

(86) International application number:

PCT/US2016/052307

(21) Application number: **16847476.5**

(22) Date of filing: **16.09.2016**

(87) International publication number:

WO 2017/049203 (23.03.2017 Gazette 2017/12)

(54) **ENHANCED LIQUID DETECTION MECHANISMS FOR CIRCUIT CARDS**

VERBESSERTE FLÜSSIGKEITSDETEKTIONSMECHANISMEN FÜR LEITERPLATTEN

MÉCANISMES PERFECTIONNÉS DE DÉTECTION DE LIQUIDE POUR DES CARTES DE CIRCUIT
IMPRIMÉ

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

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(30) Priority: **16.09.2015 US 201562219561 P**

(43) Date of publication of application:

25.07.2018 Bulletin 2018/30

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Description

[0001] This application claims priority to U.S. provisional application having serial no. 62/219561 filed on September 16, 2015.

Field of the Invention

[0002] The field of the invention is circuit cards.

Background

[0003] The background description includes information that may be useful in understanding the present invention. It is not an admission that any of the information provided herein is prior art or relevant to the presently claimed invention, or that any publication specifically or implicitly referenced is prior art.

[0004] Electronics present a safety hazard in environments where unintentional exposure to conductive liquids by dripping, spilling, submersion and condensation are possible. Ground fault detection provides protection from electric shock. Other failure mechanisms can produce smoke, arcing and other unintentional behavior that might otherwise go undetected. Sealed enclosures are in an option in some cases where cost and thermal performance are not critical factors. Cooling holes improve heat transfer but make waterproofing requirements difficult to meet.

[0005] Printed circuit boards (PCBs) are easily damaged by conductive liquids. Some have attempted to solve this problem by indiscriminately applying a hydrophobic coating to the PCB, but imperfections in the coating can lead to short circuit related hazards and damage, especially if the liquid is present for a long time as it eventually finds its way to exposed conductors.

[0006] Detection mechanisms for liquids have also been used. Liquids are often detected by resistive measurement between two electrodes. In its simplest form, such a detection element has two conductors side by side. When a conductive liquid is poured on top of the conductors, current can now flow between them. Detection circuitry picks up a change in voltage or current and some action is taken. For example, U.S. patent no. 4,297,686 discusses this technique, shutting off water in the event of pipe leaks to prevent flooding. This and all other extrinsic materials discussed herein are incorporated by reference in their entirety. Where a definition or use of a term in an incorporated reference is inconsistent or contrary to the definition of that term provided herein, the definition of that term provided herein applies and the definition of that term in the reference does not apply.

[0007] US2015/001200 discloses systems, devices and methods for sensing moisture within an electronic device. This document discloses a device comprising a housing and a display defining an exterior of an electronic device and an interior of the electronic device. Further, the device may include an integrated circuit (IC) within

the electronic device and a control element within the electronic device. The device may also include a moisture sensor such as an inductive sensor, a capacitance sensor, or both, which may be part of the IC, and together with the control element sense moisture within the electronic device.

[0008] US2013/176700 discloses a moisture-resistant electronic device that includes at least one electronic component at least partially covered by a moisture-resistant coating. The moisture-resistant coating may be located within an interior of the electronic device and may cover only portions of a boundary of an internal space within the electronic device. A moisture-resistant-coating may include one or more discernible boundaries, or seams, which may be located at or adjacent to locations where two or more components of the electronic device interface with each other.

[0009] A very simple example of detection circuitry 100 is depicted in **Figure 1A**, which illustrates a circuit with two conductive plates that serves as detection artwork. The term "artwork" is used here because the plates could be easily implemented as circles of exposed copper on an outer layer of a circuit card. A comparator in this example handles the detection. When a conductive liquid shorts the plates as shown in **Figure 1B**, the comparator signals an alert by illuminating a light-emitting diode (LED).

[0010] Capacitive means have also been used to detect liquids. In a most basic form, such a mechanism utilizes two conductors spaced by a dielectric such as air or the substrate to which they are mounted. The conductors need not be exposed but will have a capacitance between them. As liquid approaches or contacts the sensing conductors, the dielectric properties between, and therefore capacitance between, the conductors is altered. This can then be detected by measuring circuitry and signal an action to be taken.

[0011] While these technologies each pose a potential solution to the problem of sensing liquids, they fail to address the need for the detectors to be exposed to the liquid before damage to other components may occur. In this manner, by the time the liquid is detected, damage may already have occurred.

[0012] Thus, there is still a need in the art for improved conductive liquid protection for PCBs.

Summary of the Invention

[0013] The present invention provides apparatus and methods concerning channeling conductive liquids to liquid detection artwork on a PCB, according to claims 1 and 6, and the respective dependent claims. In preferred embodiments, the presence of a conductive liquid can be detected before the PCB is damaged by the conductive liquid. Components of the PCB can be shut down upon detection of the conductive liquid, thus sparing the components from damage.

[0014] In one embodiment, a circuit card is coated such

that components on the card are largely protected from liquids, while detection artwork remains exposed to allow sensors to quickly identify the presence of conductive liquid and send a signal that results in circuitry being powered down until it is again safe to operate (e.g., the conductive liquid is removed).

[0015] In other contemplated embodiments, a coating may not be necessary. Instead, the structure of the enclosure or components or features attached to the circuit card can be used to steer liquid towards detection artwork. Again, the detection artwork can then signal the presence of liquid to cause circuitry to be shut down.

[0016] It is also contemplated that circuit cards could include liquid steering in their structure at the time of manufacture. For example, etched or routed openings on the circuit cards can be used to channel liquid to detection artwork in lower layers. In one contemplated embodiment, copper shapes on the surface are physically raised relative to areas void of copper. This property of circuit card design may be exploited to steer and pool liquids around detection artwork.

[0017] Various objects, features, aspects and advantages of the inventive subject matter will become more apparent from the following detailed description of preferred embodiments, along with the accompanying drawing figures in which like numerals represent like components.

Brief Description of the Drawing

[0018]

Figures 1A-1B shows a prior art circuit diagram to illustrate one possible implementation of simple detection artwork.

Figure 2 is a perspective view of one embodiment of a circuit card assembly with liquid detection artwork etched into the circuit card beside other circuit components.

Figure 3 shows the circuit card assembly of Figure 2 with liquid present.

Figures 4A-4C shows an improved circuit card design concept such that the exposed detection artwork is the most susceptible component to the presence of liquids.

Figure 5 shows the circuit card assembly of Figure 4C with liquid present.

Figure 6 shows another embodiment of a circuit card assembly structured to channel liquid flow along the circuit card.

Figure 7 shows another embodiment of a circuit card assembly having a curved or flex configuration.

Detailed Description

[0019] The following discussion provides example embodiments of the inventive subject matter. Although each embodiment represents a single combination of inventive elements, the inventive subject matter is considered to include all possible combinations of the disclosed elements. Thus if one embodiment comprises elements A, B, and C, and a second embodiment comprises elements B and D, then the inventive subject matter is also considered to include other remaining combinations of A, B, C, or D, even if not explicitly disclosed.

[0020] As used in the description herein and throughout the claims that follow, the meaning of "a," "an," and "the" includes plural reference unless the context clearly dictates otherwise. Also, as used in the description herein, the meaning of "in" includes "in" and "on" unless the context clearly dictates otherwise.

[0021] Also, as used herein, and unless the context dictates otherwise, the term "coupled to" is intended to include both direct coupling (in which two elements that are coupled to each other contact each other) and indirect coupling (in which at least one additional element is located between the two elements). Therefore, the terms "coupled to" and "coupled with" are used synonymously.

[0022] In some embodiments, the numbers expressing quantities of ingredients, properties such as concentration, reaction conditions, and so forth, used to describe and claim certain embodiments of the invention are to be understood as being modified in some instances by the term "about." Accordingly, in some embodiments, the numerical parameters set forth in the written description and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by a particular embodiment.

[0023] It should be noted that any language directed to a computer should be read to include any suitable combination of computing devices, including servers, interfaces, systems, databases, agents, peers, Engines, controllers, or other types of computing devices operating individually or collectively. One should appreciate the computing devices comprise a processor configured to execute software instructions stored on a tangible, non-transitory computer readable storage medium (e.g., hard drive, solid state drive, RAM, flash, ROM, etc.). The software instructions preferably configure the computing device to provide the roles, responsibilities, or other functionality as discussed below with respect to the disclosed apparatus. In especially preferred embodiments, the various servers, systems, databases, or interfaces exchange data using standardized protocols or algorithms, possibly based on HTTP, HTTPS, AES, public-private key exchanges, web service APIs, known financial transaction protocols, or other electronic information exchanging methods. Data exchanges preferably are conducted over a packet-switched network, the Internet, LAN, WAN, VPN, or other type of packet switched network. The following description includes information that may be use-

ful in understanding the present invention. It is not an admission that any of the information provided herein is prior art or relevant to the presently claimed invention, or that any publication specifically or implicitly referenced is prior art.

[0024] To prevent conductive liquids (e.g., water) from damaging a PCB, the inventors discovered that a printed circuit board can be configured via structure or components (i.e., using the PCB itself or materials added to the PCB) to route liquids toward detection artwork. The detection artwork can include one or more sensors with simple circuitry to power down electronics in the presence of conducting liquids. Such detection artwork can include, for example, shaped pads, vias, and traces. In this manner, when conductive fluid comes into contact with the detection artwork, such as that shown in the figures, a circuit is completed that can be used to directly or indirectly power down hazardous circuitry safely or signal that components should be powered down.

[0025] It is further contemplated that the PCB can include detection artwork that interferes with ingress of liquid into an electronics enclosure. For example, in some embodiments, the PCB can be printed to have features on its surface that direct the flow of liquid that comes into contact with the PCB to the detection artwork. Such features can include, for example, selectively raised coatings and etched, routed, or other topographic features that help to channel liquid. In still other embodiments, a coating can be selectively applied to the PCB such that liquid is steered across the PCB. In each of these embodiments, the result is that the conductive fluid is directed to the detection artwork and preferably away or at least not toward sensitive components.

[0026] **Figure 2** depicts a typical circuit card assembly 200 comprising a circuit card 202 with various components 204, 206 disposed on the card 202. Liquid detection artwork 210 is etched into the circuit card 202.

[0027] **Figure 3** illustrates circuit card assembly 200 of **Figure 2** having liquid 220 disposed on the card 202. Because of the card's configuration, components have as much as a probability of coming into contact with the liquid as the detection artwork 210.

[0028] **Figures 4A-4C** depict the stages of manufacture of another embodiment of a circuit card assembly 300 comprising a circuit card 302. In **Figure 4A**, the detection artwork 310 is first masked onto the card 302. In **Figure 4B**, the circuit card 302 including the detection artwork 310 and components 304, 306 are coated with a coating 312. Finally, in **Figure 4C**, the mask over the detection artwork 310 is stripped away leaving a channel 314, and exposing the detection artwork 310 while the other components 304, 306 remain coated. In such embodiment, the coated components 304, 306 are advantageously kept from being contacted with a liquid and the channel 314 can be used to direct liquid to the detection artwork 310.

[0029] **Figure 5** shows the circuit card assembly 300 depicted in **Figure 4C** exposed to liquid. In contrast to

what is shown in **Figure 3**, the coating 312 lowers the probability of component shorting. At the same time, the exposed detection artwork 310 has an increased probability of coming into contact with the liquid, as gravity will draw any standing liquid drops into the detection artwork 310, such as via channel 314.

[0030] In some embodiments, it is contemplated that the coating could be further tapered to provide a downward slope toward the channel 314 to further assist in directing liquid flow to the channel 314 and detection artwork 310.

[0031] All the figures thus far have dealt with liquid coming from the top. **Figure 6** depicts another embodiment of a circuit card assembly 400 having a circuit card 402 that includes channels 411, 413, which advantageously direct liquid flow laterally along the circuit card 402, such as to channel 414 and detection artwork 410. Again, gravity contains liquid within the channels 411, 413. By adding one or more additional channels, which preferably are approximately perpendicular to channel 414 that comprises detection artwork 410, the area of coverage of the detection artwork 410 is increased due to the increase number of paths or channels leading to the detection artwork 410.

[0032] These channels may or may not include features to slope toward the detection artwork.

[0033] Although the above examples discuss the deposition of a coating on a circuit card, other techniques could be used without departing from the scope of the inventive concepts described herein. For example, similar results can be accomplished by including on the circuit card routing channels, raised etches on the circuit card and its layers, or molded features placed over the top of circuits. Still further, inner layers of a circuit card could be used, drilling or cutting could be used, as well as other methods that expose underlying detection artwork.

[0034] **Figure 7** depicts a circuit card assembly 500 having a circuit card 502 with a curved or flex circuit configuration. In such embodiment, the card 502 can include exposed detection artwork 510 that signals when liquid is present. The flex or curved configuration of the circuit card 502 advantageously directs liquid to the detection artwork 510 (and away from components) via gravity. It is contemplated that a cable or flex assembly with selectively exposed conductors could be used as such the detection artwork 510. As used herein, the term "flex assembly" includes both flex cable and rigid flex. Contemplated flex assembly include, for example, simple wire in insulator type cables, flex cables and rigid flex assemblies that mix PCB and flex cable technologies.

Claims

1. A circuit card assembly (200, 300, 400, 500), comprising:

- a circuit card (202, 302, 402, 502) having one or more components (204, 206, 304, 306, 404, 406);
 a surface coating (312, 412) that encloses the one or more components such that they are protected from exposure to liquids (220, 320, 520);
characterised by
 a first channel (314, 414) comprising an etched or routed opening in the coating that directs liquid to detection artwork (210, 310, 410, 510);
 wherein the detection artwork is disposed within the first channel; and
 wherein the first channel is defined on first and second sidewalls by the coating, and the first channel is configured to direct liquid present on the circuit card to the detection artwork.
2. The circuit card assembly of claim 1, further comprising a second channel (411, 413) arranged in a direction that is perpendicular to a direction of the first channel, and wherein the second channel is defined on first and second sidewalls by the coating.
 3. The circuit card assembly of claim 1 or 2, further comprising one or more components disposed on the circuit card and underneath the coating.
 4. The circuit card assembly of any of claims 1-3, wherein the detection artwork comprises shaped pads, vias, or traces.
 5. The circuit card assembly of any of claims 1-4, wherein the detection artwork comprises one or more sensors configured to send a signal when a liquid is present.
 6. A method of forming a circuit card assembly (200, 300, 400, 500) according to claim 1, comprising:
 - applying a mask to a detection artwork disposed on a circuit card (202, 302, 402, 502);
 - coating the circuit card and detection artwork;
 - removing the mask over the detection artwork to form a channel (314, 414) and expose the detection artwork;
 - wherein first and second sidewalls of the channel are defined by the coating; and
 - wherein the detection artwork and one or more components are electrically coupled such that detection of liquid (220, 320, 520) by the detection artwork results in powering down of the one or more components.
 7. The method of claim 6, removing the coating from a second portion of the circuit card to form a second channel (411, 413).
 8. The method of claim 7, wherein the second channel

is defined on first and second sidewalls by the coating, and wherein the second channel intersects with the channel.

9. The method of any of claims 6-8, wherein the detection artwork comprises shaped pads, vias, or traces.
10. The method of any of claims 6-9, wherein the detection artwork comprises a sensor configured to send a signal when a liquid is present.
11. The circuit card assembly of any of claims 1-5, further comprising a plurality of channels that intersect one another to form a grid, such that liquid can flow within the grid to the detection artwork.
12. The circuit card assembly of any of claims 1-5 and 11, wherein the first channel is tapered such that liquid flows toward the detection artwork.
13. The circuit card assembly of any of claims 1-5 and 11-12, wherein the first channel comprises a selectively raised coating such that liquid flow is directed toward the detection artwork.
14. The circuit card assembly of any of claims 1-5 and 11-13, wherein the first channel is configured and disposed on the card such that gravity will accumulate liquid at the detection artwork.

Patentansprüche

1. Schaltkartenanordnung (200, 300, 400, 500), umfassend:
 - eine Schaltkarte (202, 302, 402, 502), die eine oder mehrere Komponenten (204, 206, 304, 306, 404, 406) aufweist;
 - eine Oberflächenbeschichtung (312, 412), die die eine oder mehreren Komponenten derart umschließt, dass sie vor einer Einwirkung von Flüssigkeiten (220, 320, 520) geschützt sind;
 - gekennzeichnet durch** einen ersten Kanal (314, 414), der eine geätzte oder geführte Öffnung in der Beschichtung umfasst, die Flüssigkeit zu einer Erfassungsvorlage (210, 310, 410, 510) leitet;
 - wobei die Erfassungsvorlage innerhalb des ersten Kanals angeordnet ist; und
 - wobei der erste Kanal auf ersten und zweiten Seitenwänden durch die Beschichtung definiert ist und der erste Kanal konfiguriert ist, um auf der Schaltkarte vorhandene Flüssigkeit zu der Erfassungsvorlage zu leiten.
2. Schaltkartenanordnung nach Anspruch 1, die ferner einen zweiten Kanal (411, 413) umfasst, der in einer

Richtung angeordnet ist, die senkrecht zu einer Richtung des ersten Kanals ist, und wobei der zweite Kanal auf ersten und zweiten Seitenwänden durch die Beschichtung definiert ist.

3. Schaltkartenanordnung nach Anspruch 1 oder 2, die ferner eine oder mehrere Komponenten umfasst, die auf der Schaltkarte und unter der Beschichtung angeordnet sind.

4. Schaltkartenanordnung nach einem der Ansprüche 1-3, wobei die Erfassungsvorlage geformte Bondpads, Durchkontaktierungen oder Leiterbahnen umfasst.

5. Schaltkartenanordnung nach einem der Ansprüche 1-4, wobei die Erfassungsvorlage einen oder mehrere Sensoren umfasst, die konfiguriert sind, um ein Signal zu senden, wenn eine Flüssigkeit vorhanden ist.

6. Verfahren zum Bilden einer Schaltkartenanordnung (200, 300, 400, 500) nach Anspruch 1, umfassend:

Aufbringen einer Maske auf einer auf einer Schaltkarte (202, 302, 402, 502) angeordneten Erfassungsvorlage;

Beschichten der Schaltkarte und der Erfassungsvorlage;

Entfernen der Maske über der Erfassungsvorlage, um einen Kanal (314, 414) zu bilden und die Erfassungsvorlage freizulegen;

wobei die erste und die zweite Seitenwand des Kanals durch die Beschichtung definiert sind; und

wobei die Erfassungsvorlage und eine oder mehrere Komponenten derart elektrisch gekoppelt sind, dass die Erfassung von Flüssigkeit (220, 320, 520) durch die Erfassungsvorlage zum Abschalten der einen oder der mehreren Komponenten führt.

7. Verfahren nach Anspruch 6, umfassend das Entfernen der Beschichtung von einem zweiten Abschnitt der Schaltkarte, um einen zweiten Kanal (411, 413) zu bilden.

8. Verfahren nach Anspruch 7, wobei der zweite Kanal auf ersten und zweiten Seitenwänden durch die Beschichtung definiert ist, und wobei der zweite Kanal den Kanal schneidet.

9. Verfahren nach einem der Ansprüche 6-8, wobei die Erfassungsvorlage geformte Bondpads, Durchkontaktierungen oder Leiterbahnen umfasst.

10. Verfahren nach einem der Ansprüche 6-9, wobei die Erfassungsvorlage einen Sensor umfasst, der kon-

figuriert ist, um ein Signal zu senden, wenn eine Flüssigkeit vorhanden ist.

11. Schaltkartenanordnung nach einem der Ansprüche 1-5, die ferner mehrere Kanäle umfasst, die einander schneiden, um ein Gitters derart zu bilden, dass Flüssigkeit innerhalb des Gitters zu der Erfassungsvorlage fließen kann.

12. Schaltkartenanordnung nach einem der Ansprüche 1-5 und 11, wobei der erste Kanal derart verjüngt ist, dass Flüssigkeit zu der Erfassungsvorlage fließen kann.

13. Schaltkartenanordnung nach einem der Ansprüche 1-5 und 11-12, wobei der erste Kanal eine selektiv erhabene Beschichtung derart aufweist, dass der Flüssigkeitsfluss auf die Erfassungsvorlage gerichtet ist.

14. Schaltkartenanordnung nach einem der Ansprüche 1-5 und 11-13, wobei der erste Kanal derart konfiguriert und auf der Platte angeordnet ist, dass sich durch Schwerkraft Flüssigkeit an der Erfassungsvorlage ansammelt.

Revendications

1. Ensemble de cartes imprimées (200, 300, 400, 500), comprenant :

une carte imprimée (202, 302, 402, 502) ayant un ou plusieurs composants (204, 206, 304, 306, 404, 406) ;

un revêtement de surface (312, 412) qui renferme le ou les composants de telle sorte qu'ils sont protégés d'une exposition à des liquides (220, 320, 520) ;

caractérisé par

un premier canal (314, 414) comprenant une ouverture gravée ou orientée dans le revêtement qui dirige le liquide vers le dessin de détection (210, 310, 410, 510) ;
dans lequel le dessin de détection est disposé à l'intérieur du premier canal ; et
dans lequel le premier canal est défini sur les première et seconde parois latérales par le revêtement, et le premier canal est conçu pour diriger le liquide présent sur la carte imprimée vers le dessin de détection.

2. Ensemble de cartes imprimées selon la revendication 1, comprenant en outre un second canal (411, 413) agencé dans une direction qui est perpendiculaire à une direction du premier canal, et dans lequel

le second canal est défini sur les première et seconde parois latérales par le revêtement.

3. Ensemble de cartes imprimées selon la revendication 1 ou 2, comprenant en outre un ou plusieurs composants disposés sur la carte imprimée et sous le revêtement. 5
4. Ensemble de cartes imprimées selon l'une quelconque des revendications 1 à 3, dans lequel le dessin de détection comprend des plots, des vias ou des tracés profilés. 10
5. Ensemble de cartes imprimées selon l'une quelconque des revendications 1 à 4, dans lequel le dessin de détection comprend un ou plusieurs capteurs configurés pour émettre un signal lorsqu'un liquide est présent. 15
6. Procédé de formation d'un ensemble de cartes imprimées (200, 300, 400, 500) selon la revendication 1, comprenant : 20
 - l'application d'un masque à un dessin de détection disposé sur une carte imprimée (202, 302, 402, 502) ; 25
 - le revêtement de la carte imprimée et du dessin de détection ;
 - le retrait du masque sur le dessin de détection pour former un canal (314, 414) et exposer le dessin de détection ; 30
 - dans lequel les première et seconde parois latérales du canal sont définies par le revêtement ;
 - et
 - dans lequel le dessin de détection et un ou plusieurs composants sont couplés électriquement de telle sorte que la détection de liquide (220, 320, 520) par le dessin de détection entraîne la mise hors tension du ou des composants. 35
7. Procédé selon la revendication 6, le retrait du revêtement d'une seconde partie de la carte imprimée pour former un second canal (411, 413). 40
8. Procédé selon la revendication 7, dans lequel le second canal est défini sur les première et seconde parois latérales par le revêtement, et dans lequel le second canal croise le canal. 45
9. Procédé selon l'une quelconque des revendications 6 à 8, dans lequel le dessin de détection comprend des plots, des vias ou des tracés profilés. 50
10. Procédé selon l'une quelconque des revendications 6 à 9, dans lequel le dessin de détection comprend un capteur configuré pour émettre un signal lorsqu'un liquide est présent. 55

11. Ensemble de cartes imprimées selon l'une quelconque des revendications 1 à 5, comprenant en outre une pluralité de canaux qui se croisent pour former une grille, de telle sorte que le liquide puisse s'écouler à l'intérieur de la grille vers le dessin de détection.
12. Ensemble de cartes imprimées selon l'une quelconque des revendications 1 à 5 et 11, dans lequel le premier canal est effilé de telle sorte que le liquide s'écoule vers le dessin de détection.
13. Ensemble de cartes imprimées selon l'une quelconque des revendications 1 à 5 et 11 à 12, dans lequel le premier canal comprend un revêtement sélectivement surélevé de telle sorte que l'écoulement de liquide est dirigé vers le dessin de détection.
14. Ensemble de cartes imprimées selon l'une quelconque des revendications 1 à 5 et 11 à 13, dans lequel le premier canal est conçu et disposé sur la carte de telle sorte que la gravité accumulera du liquide au niveau du dessin de détection.

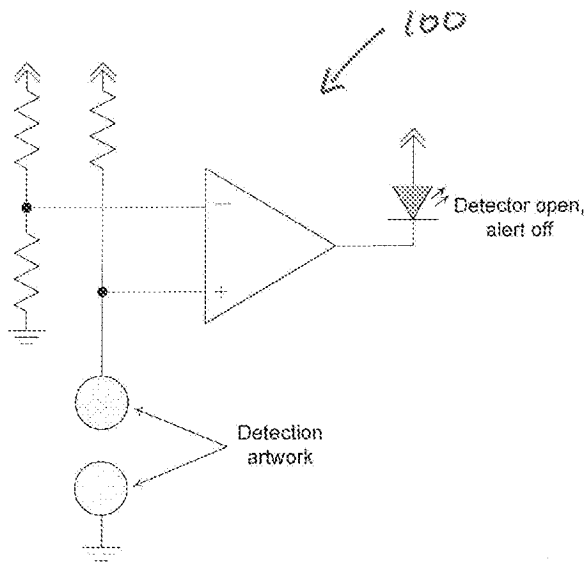


Figure 1A
(Prior Art)

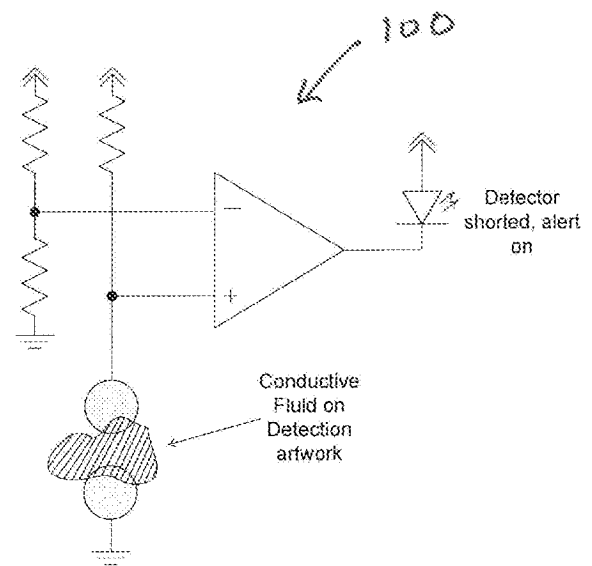


Figure 1B
(Prior Art)

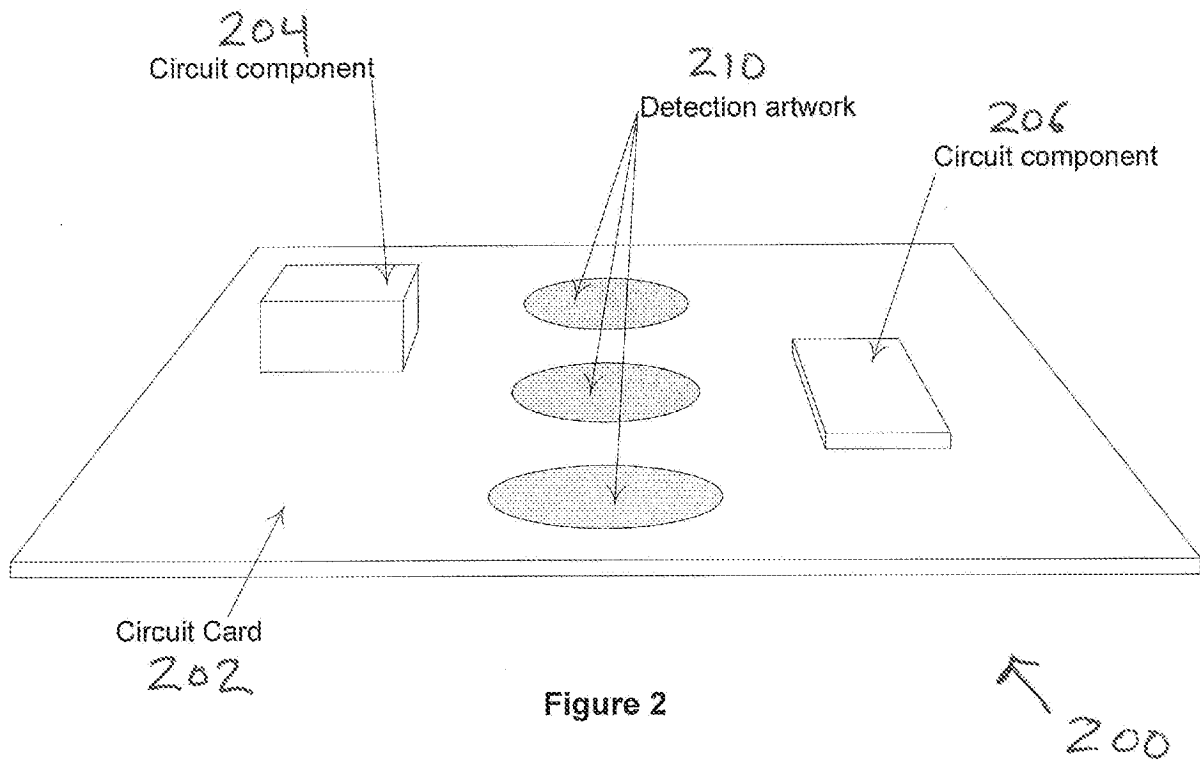
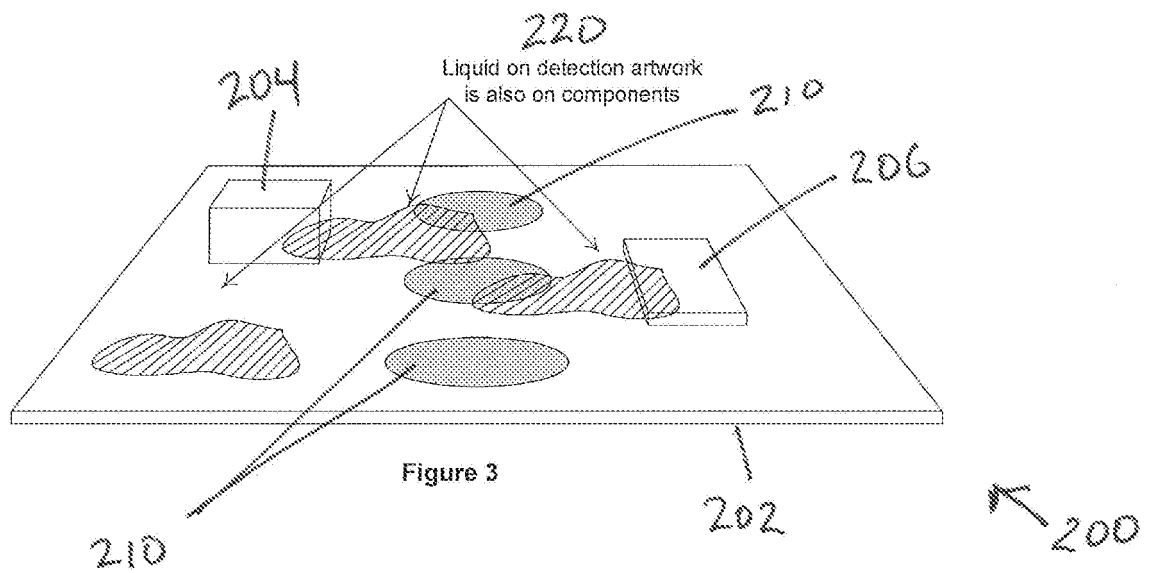
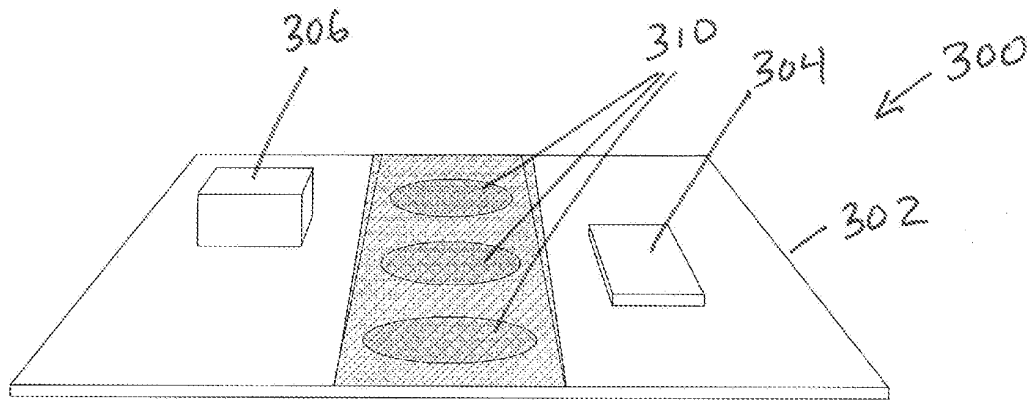


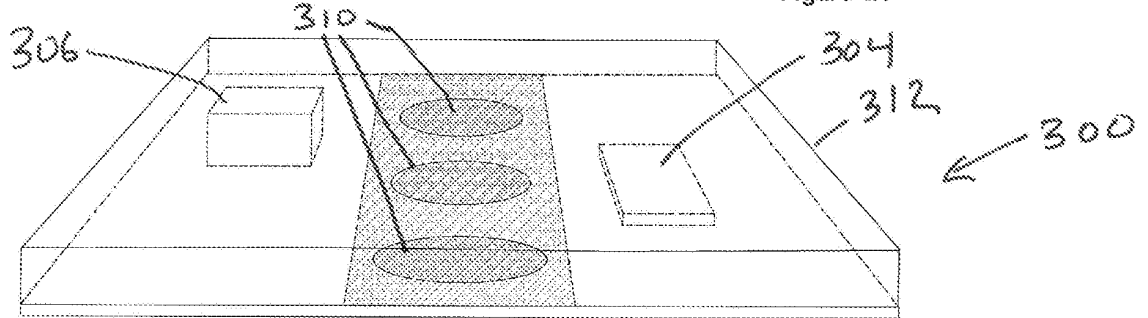
Figure 2





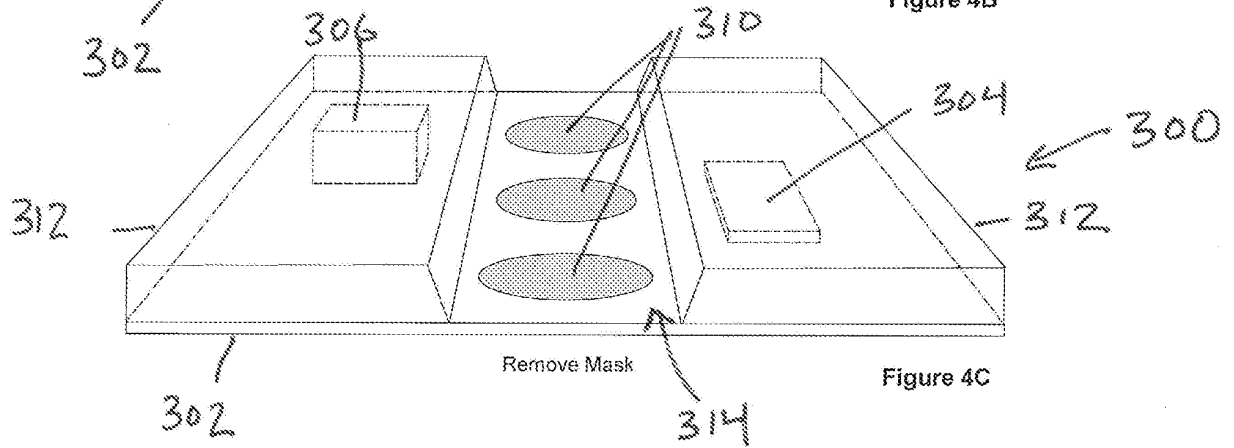
Mask Detection Artwork

Figure 4A



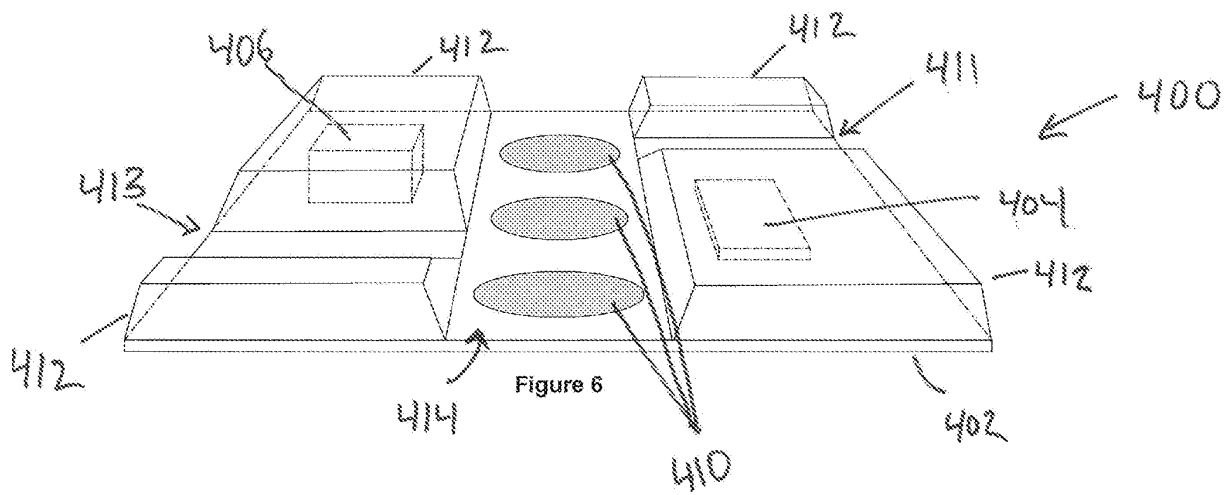
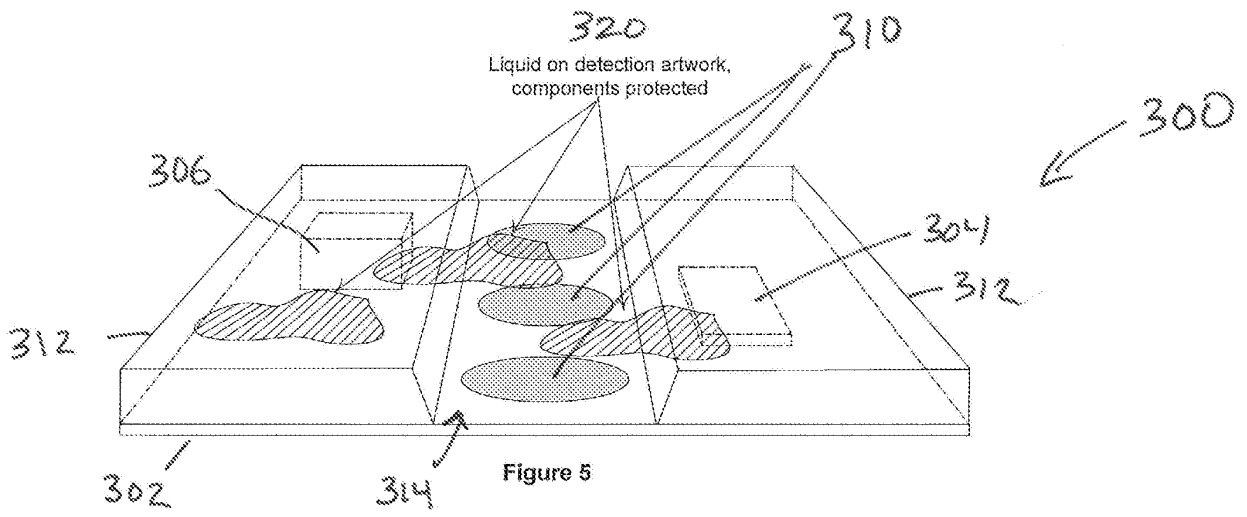
Coat Circuit Card Assembly

Figure 4B



Remove Mask

Figure 4C



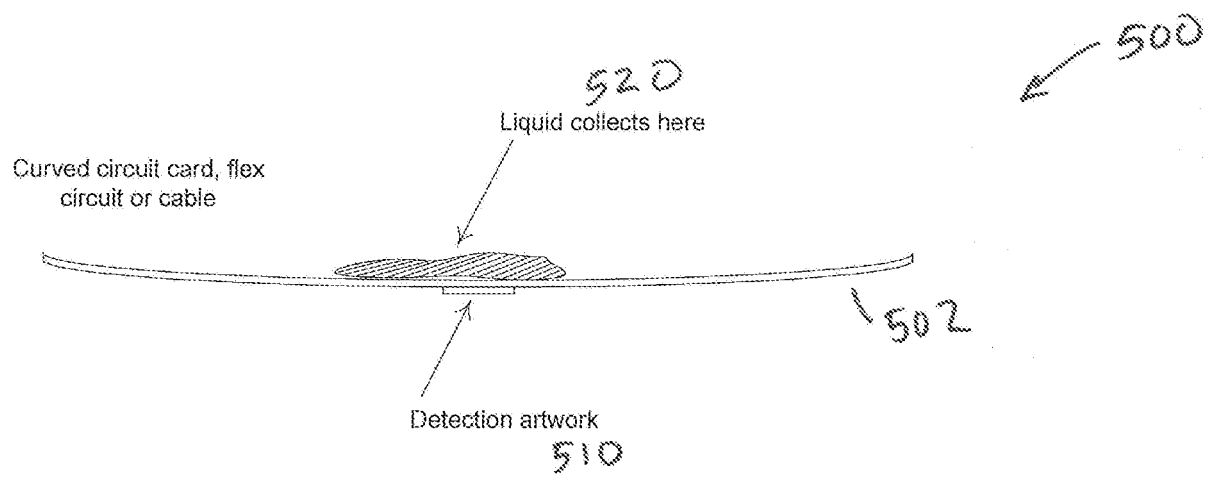


Figure 7

REFERENCES CITED IN THE DESCRIPTION

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